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ECBC-TR-811

### CAPILLARY DIAMETER VARIATION FOR THE INTEGRATED VIRUS DETECTION SYSTEM (IVDS)

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| <b>14. ABSTRACT</b><br>Several capillary sizes are available for injecting samples into the IVDS via the electrospray module. All of the capillaries have the same outside diameter (o.d.) but different inside diameters (i.d.). This report explores the results of changing the i.d. of the capillary used on the IVDS instrument and the resulting impact on sample analysis.                         |                                |                                |                                   |  |  |                 |                                |                               |                   |                     |     |                    |                        |  |
| <b>15. SUBJECT TERMS</b> <table border="0" style="width: 100%;"><tr><td style="width: 33%;">Virus detection</td><td style="width: 33%;">Differential mobility analyzer</td><td style="width: 33%;">Condensation particle counter</td></tr><tr><td>Biological agents</td><td>Virus concentration</td><td>MS2</td></tr><tr><td>Capillary diameter</td><td>Electrospray injection</td><td></td></tr></table> |                                |                                |                                   |  |  | Virus detection | Differential mobility analyzer | Condensation particle counter | Biological agents | Virus concentration | MS2 | Capillary diameter | Electrospray injection |  |
| Virus detection   | Differential mobility analyzer | Condensation particle counter  |                                   |  |  |                 |                                |                               |                   |                     |     |                    |                        |  |
| Biological agents   | Virus concentration            | MS2                            |                                   |  |  |                 |                                |                               |                   |                     |     |                    |                        |  |
| Capillary diameter  | Electrospray injection         |                                |                                   |  |  |                 |                                |                               |                   |                     |     |                    |                        |  |
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## PREFACE

The work described in this report was started in October 2004 and completed in July 2005.

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## CAPILLARY DIAMETER VARIATION FOR THE INTEGRATED VIRUS DETECTION SYSTEM (IVDS)

### 1. INTRODUCTION

In this report, we explore the effect of changing the capillary inlet size of the electrospray injection module of the IVDS system. There are several inside diameter (i.d.) sizes of capillaries available for the IVDS, and the effect on the detected sample will be documented. The electrospray module aerosolizes the virus containing solution and injects a monodispersed aerosol solution into the air stream for analysis. The electrospray converts the sample to an aerosol by charging the liquid with an electric potential, pushing it through a capillary, and exerting an electric field at the capillary tip. The liquid evaporates from the droplets formed at the capillary tip and is carried into the sizing and counting modules of the IVDS. A change in the i.d. of the capillary may be significant on the detected concentration due to the close proximity of the capillary and the aerosolization of the virus sample.

The parameters associated with the electrospray module are air and CO<sub>2</sub> flow, sample overpressure, electrical voltage, and amperage. The air and CO<sub>2</sub> flows are fixed and not variable. The overpressure needs to be at a minimum (between 3 and 5 psi) to maintain a flow through the capillary. The only parameter with any variability is the setting of the electrical voltage that exerts the electric field at the capillary tip. This parameter was controlled to a stable range of voltages when the MS2 bacteriophage was analyzed. Although the amperage changes with voltage, the amperage is not operator adjustable. As shown in ECBC-TR-462,\* as long as the voltages are within the stable range, the sample analyses will be consistent.

#### 1.1 Capillary Diameter Procedures - MS2

Tests were run to determine the optimum i.d. for samples in the IVDS. The capillaries available were 25, 30, and 40  $\mu\text{m}$  i.d. The outside diameter (o.d.) of the capillaries did not change. A sample of MS2 was analyzed in the IVDS with consistent machine parameters with the three available capillaries. The scans for the 25, 30, and 40  $\mu\text{m}$  i.d. capillaries were averaged for each capillary, and the results for each are shown in Figures 1-3. The counts in the region of interest (ROI), from 22.5 to 28.9 nm, for MS2 increased with each increase in the capillary i.d. The data compilation in the table shows an increase of 3,206; 7,502; and 31,807 counts for the 25, 30, and 40  $\mu\text{m}$  i.d. capillaries, respectively.

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\* Wick, C.H.; McCubbin, P.E. *Stability of IVDS Electrospray Module During Analysis of MS2 Bacteriophage*; ECBC-TR-462; U.S. Army Edgewood Chemical Biological Center: Aberdeen Proving Ground, MD, 2005; UNCLASSIFIED Report (AD-A443 028).

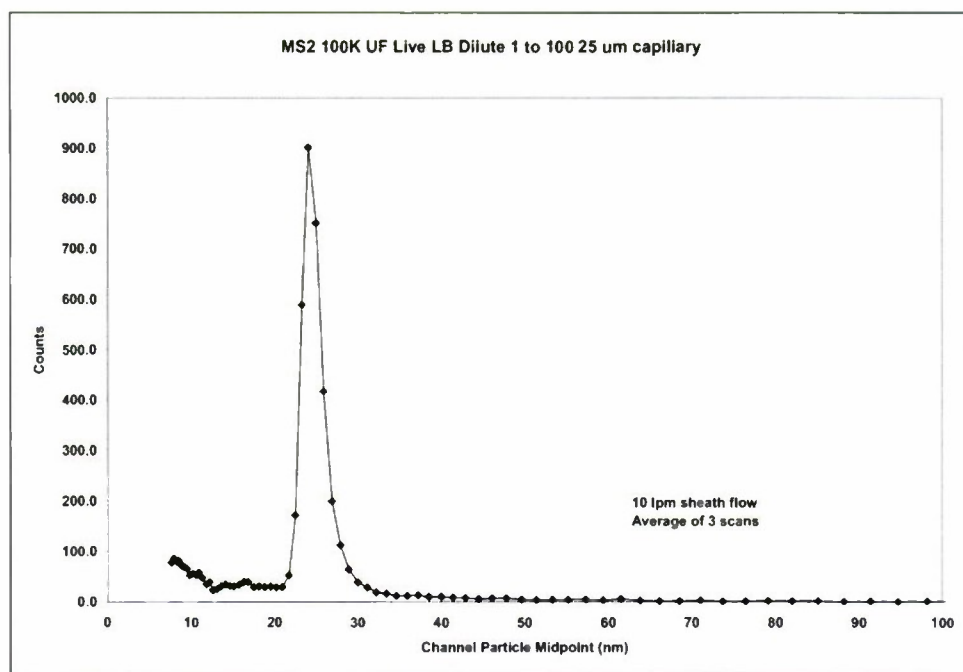


Figure 1. 25  $\mu$ m Capillary Analysis of MS2

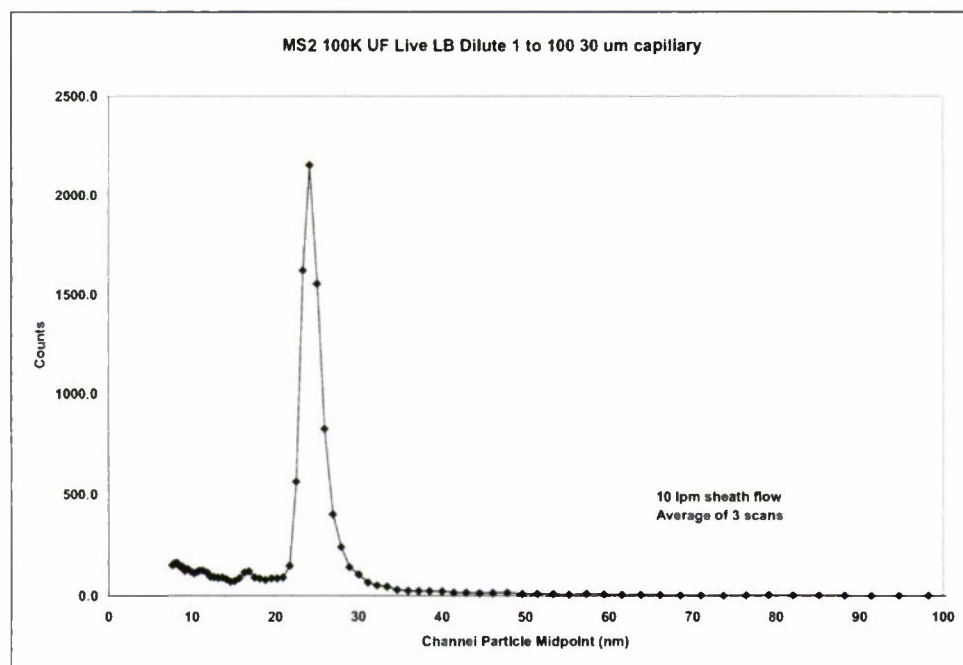


Figure 2. 30  $\mu$ m Capillary Analysis of MS2

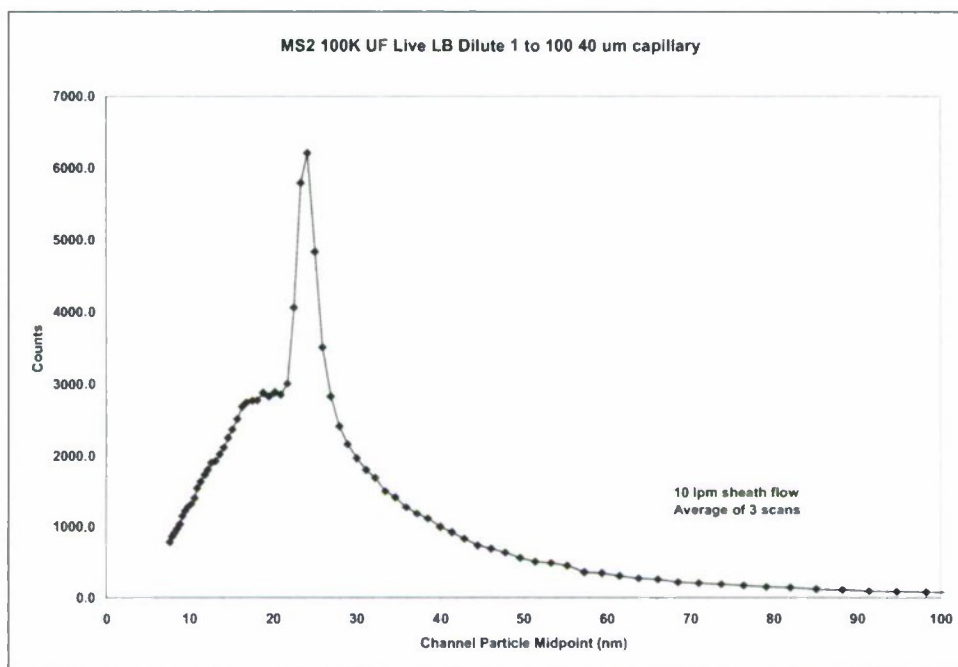


Figure 3. 40  $\mu\text{m}$  Capillary Analysis of MS2

Table. Capillary Data from 25, 30, and 40  $\mu\text{m}$  i.d. Capillaries

| Capillary diameter           |  |                  |
|------------------------------|--|------------------|
| Counts in ROI                |  |                  |
| 25 $\mu\text{m}$             | 30 $\mu\text{m}$                         | 40 $\mu\text{m}$ |
| 3206                         | 7502                                     | 31807            |
|                              | Multiplier from previous column (counts) |                  |
|                              | 2.3                                      | 4.2              |
| i.d. area in $\mu\text{m}^2$ |  |                  |
| 491                          | 707                                      | 1256             |
|                              | Multiplier from previous column (area)   |                  |
|                              | 1.4                                      | 1.8              |

## 1.2 Capillary Procedures - Buffer Solution

A similar set of analyses was performed on the standard buffer solution, 20 mM ammonium acetate, used in the IVDS. This buffer is used because of the very low count rate across the IVDS' scan area.. The three capillary sizes were used to analyze the ammonium acetate solution and are shown in Figures 4-6. The counts for the 25 and 30  $\mu\text{m}$  capillaries were acceptable across the scan range. The counts for the 40  $\mu\text{m}$  capillary, although still acceptable

for many virus analyses, were much higher than the 25 or 30  $\mu\text{m}$  capillaries. The higher count rates for the 40  $\mu\text{m}$  capillary may interfere with analyses of smaller viruses in the IVDS.

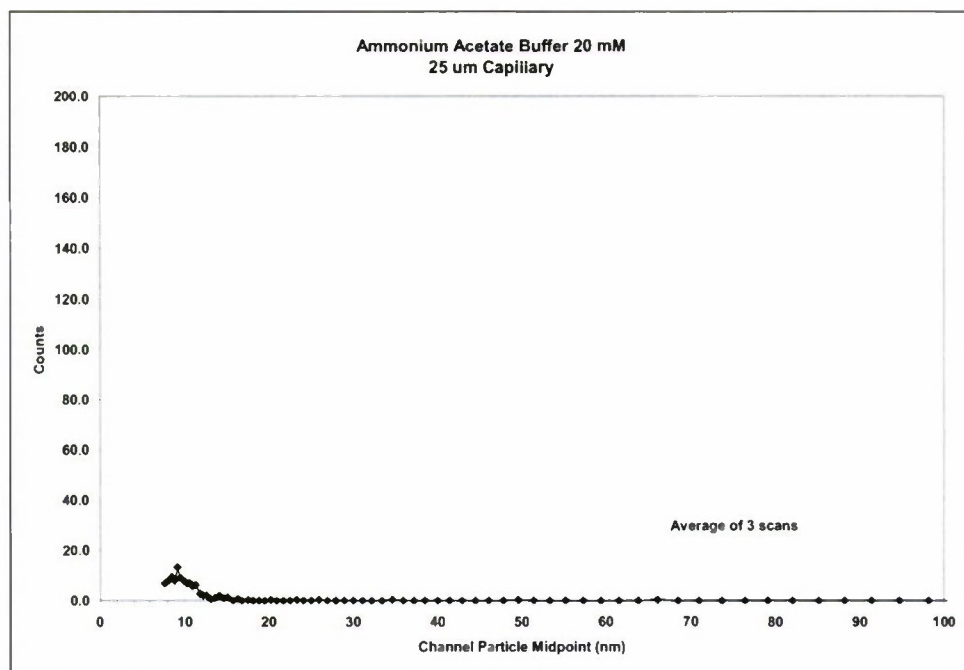


Figure 4. Ammonium Acetate Analysis with 25  $\mu\text{m}$  Capillary

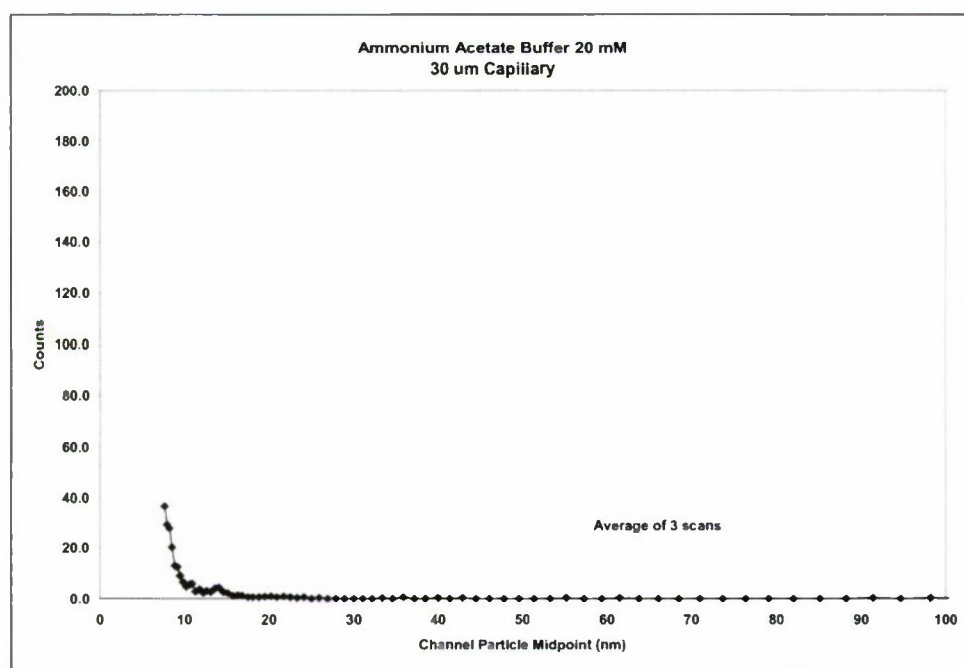


Figure 5. Ammonium Acetate Analysis with 30  $\mu\text{m}$  Capillary

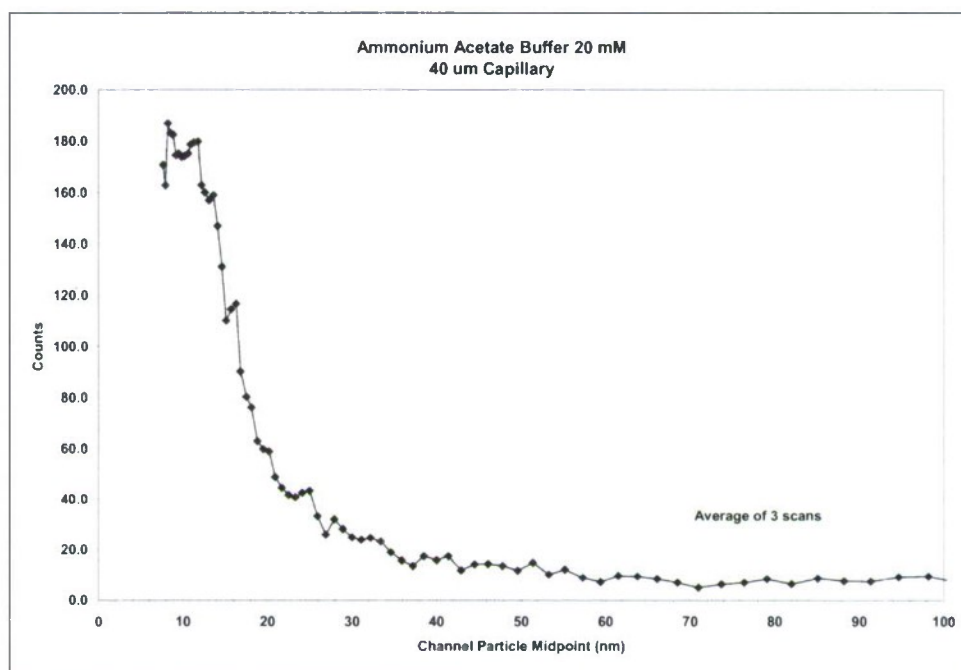


Figure 6. Ammonium Acetate Analysis with 40  $\mu\text{m}$  Capillary

### 1.3 Capillary Results

The increase in counts from one capillary size to the next is 2.3 times for the 25 to 30  $\mu\text{m}$  and 4.2 times for the 30 to 40  $\mu\text{m}$ . However, the increase in i.d. area for the same capillaries is only 1.4 times for the 25 to 30  $\mu\text{m}$  and 1.8 times for the 30 to 40  $\mu\text{m}$ . The increase in counts may seem to be a positive factor in the analysis of viruses, i.e., more counts would make viruses easier to detect. A closer analysis of the scans shows a marked increase in the background levels in the IVDS analysis using the 40  $\mu\text{m}$  capillary. The background only starts to reach an acceptable level at  $\sim 100$  nm. The majority of viruses have sizes up to  $\sim 150$  nm, and the increased background might hamper the analysis of many viruses. In addition, viruses below 40 nm in size, such as the intestinal viruses between 25 and 35 nm, are of great interest due to the severity of illness in certain segments of the population, and may be difficult to analyze at all due to the very high background counts seen in the largest capillary results.

## 2. CAPILLARY CONCLUSIONS

The large background resulting from the 40  $\mu\text{m}$  capillary would interfere with viral analysis unless the virus sample concentration was very high. The high background would also make any attempt at sample quantification virtually impossible. The recommended capillary sizes for virus analysis with the IVDS are the 25 and 30  $\mu\text{m}$  i.d. capillaries. However, it is strongly recommended to know the capillary in use at the time of analysis, and not to mix capillaries when performing similar analyses on samples. To mix capillaries, especially on counting or concentration studies, could lead to extraneous results.